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## (54) Electromagnetic transmission system

(57) An electromagnetic transmission system comprises an input rotor (1), arranged concentrically with an output rotor (2) and (3) within a casing (5) and (6). Drive is supplied to the input rotor (1), which contains magnets, and causes rotating magnetic fields to be produced in both the output rotor (2) and (3) and the casing (5) and (6). Interaction of the magnetic fields causes the output rotor (2) and (3) to rotate. The output speed and torque can be controlled by adjusting the angular position of casing (5) with respect to casing (6). Additional electrical power can be imported to provide additional or the only motive power. Electrical power can also be exported to provide a brake or to charge a battery. A lock up may be provided. Vehicle applications and a method of obtaining reverse gearing are disclosed.

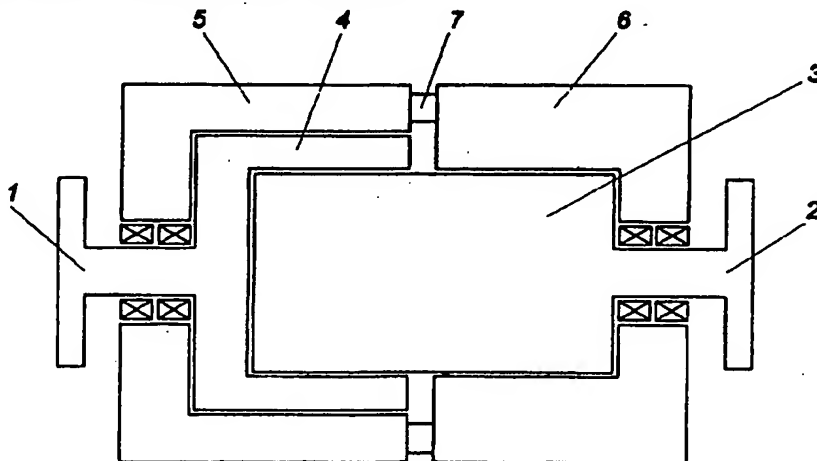


FIG. 1

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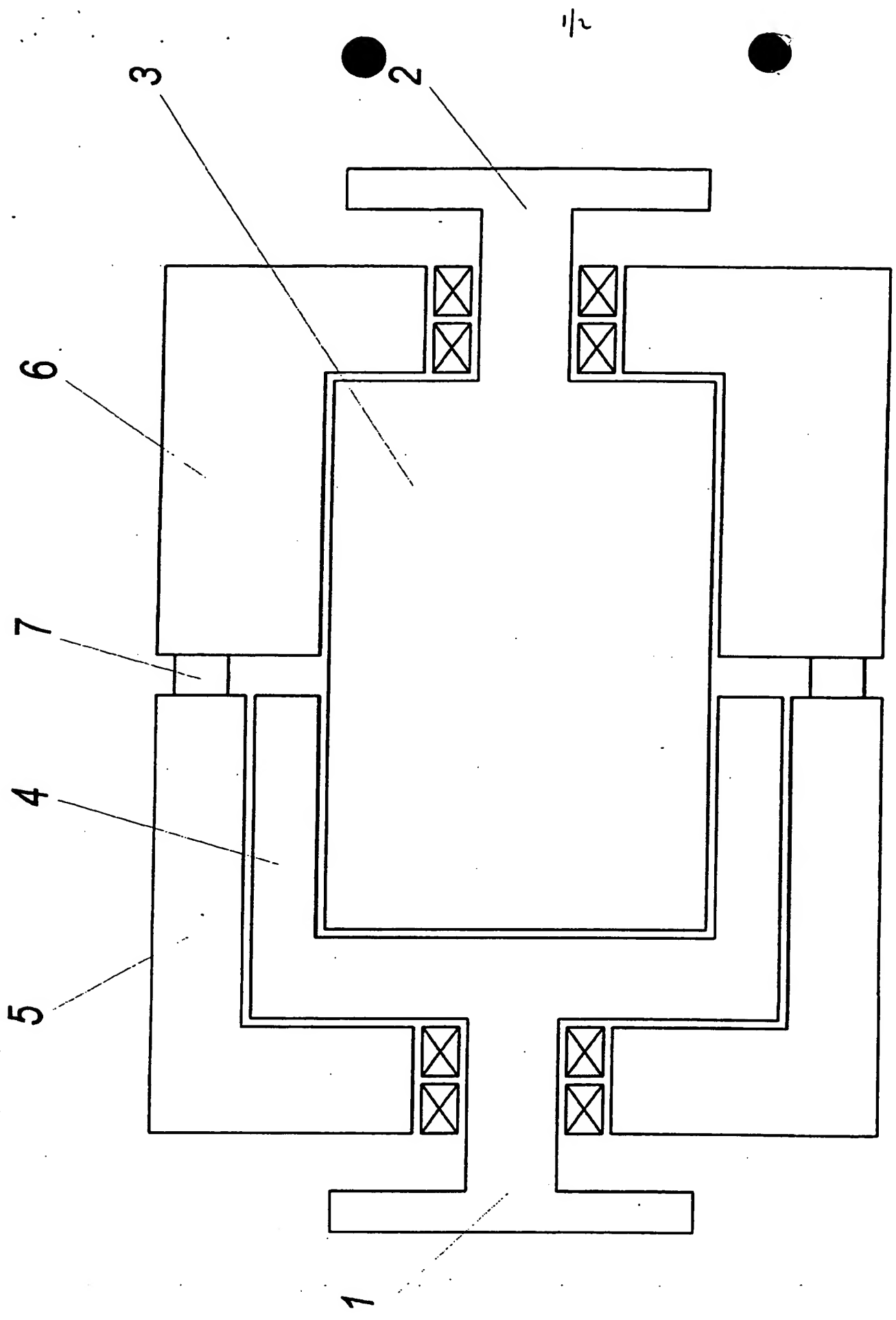
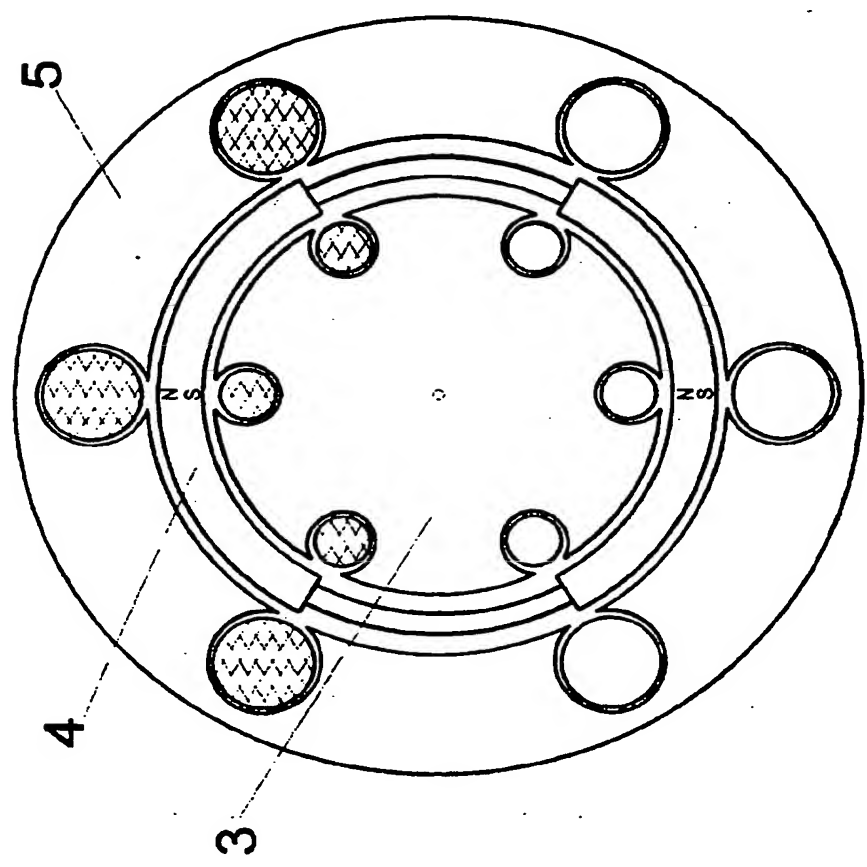
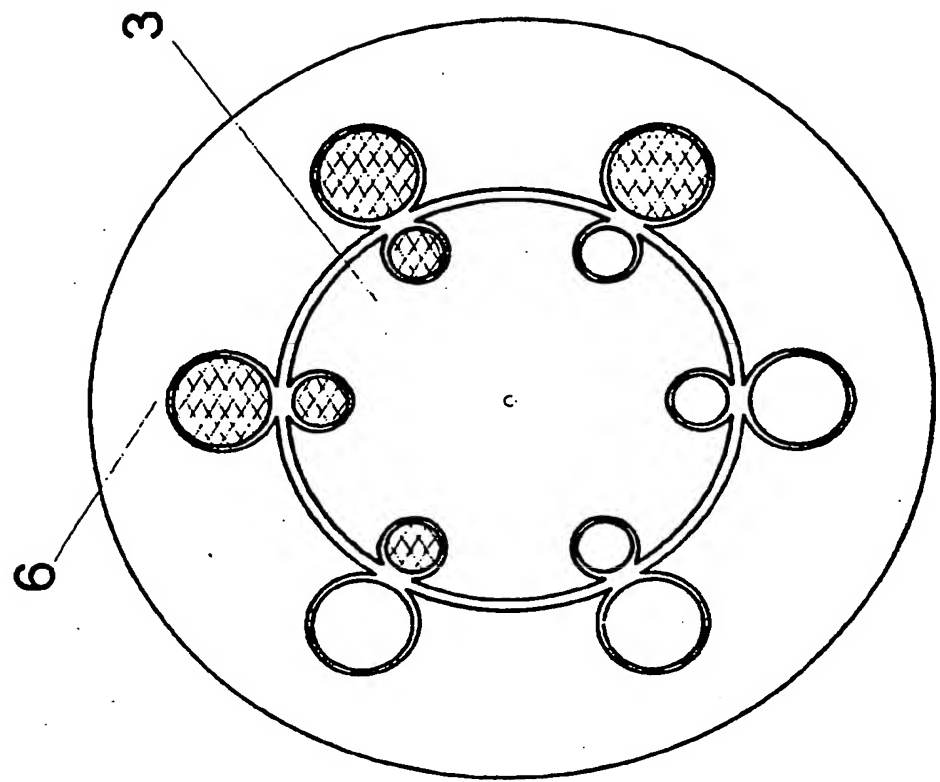


FIG. 1

FIG. 2



## ELECTROMAGNETIC TRANSMISSION SYSTEM

The invention relates to an electromagnetic transmission.

Road vehicles require a form of transmission which would provide different overall ratios and tractive effort to suit conditions ranging from climbing steep gradients or accelerating to a maximum driving speed on level ground. Ideally this would be accomplished by a form of infinitely variable transmission giving a first gear ratio upon starting and progressively altering the ratio during operation.

Five-speed manual gearboxes and four-speed automatic gearboxes are nowadays quite common for passenger cars and up to sixteen gears may be employed for trucks. The trend toward providing more gears over recent years is an attempt to enable the engine to operate at its most economical speed over a wide range of road conditions.

An alternative to such manual gearboxes which is closer to the ideal of an infinitely variable transmission is provided by electrical transmissions. Such transmissions consist of an electrical generator coupled to the engine and electric motors at the driving wheels.

There are many industrial applications where a form of speed control is required. This is usually accomplished by using a gearbox which allows only a fixed number of ratios.

A first aspect of the invention provides an electromagnetic transmission system comprising of an input rotor containing magnetic material, an output rotor containing electrical windings and magnetic material and mounted concentrically with respect to the input rotor and an outer casing containing magnetic material and electric windings, wherein rotation of the input rotor causes a corresponding rotation of the output rotor.

Preferably, the input rotor magnetic material consists of one or more permanent magnets.

Alternatively, the input rotor magnetic material may consist of one or more electromagnets. Preferably, the electric current supplied to these electromagnets is controllable.

Preferably, the rotational speed of the output rotor is controllable independently of the input rotor's speed.

Preferably, the casing surrounds the input and output rotors, and is concentric with the input and output rotors. Alternatively the casing may be a static member arranged co-axially of the input and/or output rotor(s), the input and output rotors being arranged to revolve around the casing.

Preferably, rotation of the input rotor magnets causes a rotating magnetic field to be induced in the output rotor and the casing. Preferably, the speed of these rotating magnetic fields is proportional to input speed in both the output rotor and casing and is independent of output speed.

Preferably, switches are provided between the windings of the output rotor situated adjacent to the input rotor and the windings of the output rotor situated adjacent to the casing so that two rotating magnetic fields are created rotating in opposite directions. Similarly switches can be provided between the windings on the casing surrounding the input rotor and the windings on the casing surrounding the output rotor so that two rotating magnetic fields are created rotating in opposite directions. In this way, the output rotor can rotate in the opposite direction to the input rotor.

Preferably, the angular position of the part of the casing surrounding the input rotor is adjustable relative to the angular position of the casing surrounding the output rotor. Preferably, these two parts of the casing are linked together by resilient biasing means and angular adjustment is provided automatically. This automatic adjustment utilises the torque reaction of the input and output rotors against the resilient biasing means and allows

automatic compensation for "armature reaction" and "load angle". Alternatively, such adjustment may be provided manually. The adjustment may be locked in position.

Preferably all the current generated in the casing is allowed to flow around the casing in one or more self-contained circuits. Alternatively, some or all of the current may be extracted and used for other purposes such as for re-charging a battery or other energy storage device or powering electrical accessories. Similarly, electrical power can be imported into the casing to provide extra motive power to the output rotor.

Preferably, the output rotor and casing are each provided with a number of phase windings.

Preferably, three-phase windings are provided.

Preferably, the frameworks of the input rotor, output rotor and casing contain magnetic material to provide magnetic circuits.

A further aspect of the invention provides an infinitely variable automatic transmission for a vehicle utilising the electromagnetic transmission of the first aspect of the invention. Such a transmission may be used on road or off-road vehicles including such vehicles as bicycles or human/electric vehicles.

Preferably, the infinitely variable transmission is provided between a vehicle motor and one or more wheels.

Each wheel of the vehicle may be provided with its own infinitely variable transmission. Alternatively, a single infinitely variable transmission unit may be utilised for driving either the front wheels or the rear wheels of the vehicle.

Preferably, a lock-up device is provided for use at cruising speeds.

Drive to the input rotor may be disconnected from the vehicle motor so that the transmission may be used as an independent electrical motor for powering the vehicle.

Electrical power may be extracted from the transmission system to act as a vehicle brake. This power may be used to regenerate an energy storage device or may be dissipated as heat through a resistance.

A yet further aspect of the invention provides a speed control device for industrial applications utilising the electromagnetic transmission of the first aspect of the invention.

Preferably the input rotor is connected to an electric motor or other prime mover and the output rotor is connected to the industrial device requiring drive.

Preferably, speed control and/or direction control is achieved by adjusting the angular position of the two halves of the casing thereby adjusting the "load angle".

By way of example, specific embodiments of the present invention will now be described, with reference to the accompanying diagrammatic drawings. In which:

Figure 1 shows the major components of the transmission system.

Figure 2 shows a cross sectional view of the transmission system.

The electromagnetic transmission system has three major components: an input rotor 1, an output rotor 2 and 3 and a casing 5 and 6.

The input rotor contains two permanent magnets 4. The output rotor 3 is made of laminated soft magnetic material with six slots containing electric windings. These windings are arranged in three circuits, each winding being connected to the one directly opposite. The casing 5 and 6 is made of laminated soft magnetic material with six slots containing electric

windings. These windings are arranged in three circuits, each winding being connected to the one directly opposite.

As the input rotor magnets 4 are rotated the three-phase windings of both the output rotor 3 and the casing 5 experience an induced current caused by the differential speed of the input rotor with both components. The output rotor 3 will start to rotate at a speed less than the input rotor 1.

A rotating magnetic field will be created in both the casing 5 and the output rotor 3. In both cases this magnetic field will be rotating at input speed. In the output rotor the speed of this rotating magnetic field is independent of output speed. The emf in the windings of the output rotor is proportional to the slip speed.

The current in the windings of casing 6 will be the same as casing 5 and therefore a rotating magnetic field will exist with a speed of input speed. This rotating magnetic field will react with the output rotor 3 rotating magnetic field to produce a synchronous motor. By adjusting the angular position of casing 5 with respect to casing 6 the "load angle" of the synchronous motor can be adjusted. The torque transmitted can be adjusted from zero at 0 deg to maximum at 90 deg displacement. The output speed will be determined by the value of this torque transmitted.

Switches contained in component 7 between each winding in casing 5 and its corresponding winding in casing 6 are used to reverse the direction of the rotating magnetic field in casing 6. Switches (not shown) between the two parts of the output rotor 3 are also used to reverse the direction of the rotating magnetic field in the portion of the output rotor 3 adjacent to the casing 6. This provides a reverse gear facility. Obviously, the efficiency of the unit will be reduced in the reverse mode.

Alternatively, reverse gear can be achieved by adjusting the "load angle" by up to 90 deg in the opposite direction to the adjustment required for the forward direction.

Vehicle braking is achieved by extracting electrical power and diverting it to an energy storage device such as a flywheel or battery or to a resistance. The reverse gear facility may also be advantageously applied to provide electrical braking.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of the features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

## **CLAIMS**

1. An electromagnetic transmission system comprising an input rotor containing magnetic material, an output rotor containing electrical windings and magnetic material and mounted concentrically with respect to the input rotor and an outer casing containing electrical windings and magnetic material, wherein rotation of the input rotor creates rotating magnetic fields, which are rotating at a speed proportional to the input speed, in the output rotor and the casing, which are also mounted concentrically with respect to each other so that interaction of the rotating magnetic fields in the output rotor and the casing cause the output rotor to rotate.
2. An electromagnetic transmission system comprising an input rotor containing magnetic material, an output rotor containing electrical windings and magnetic material and mounted concentrically with respect to the input rotor and an inner static member containing electrical windings and magnetic material, wherein rotation of the input rotor creates rotating magnetic fields, which are rotating at a speed proportional to the input speed, in the output rotor and the inner stator, which are also mounted concentrically with respect to each other so that interaction of the rotating magnetic fields in the output rotor and the stator cause the output rotor to rotate.
3. A system according to claims 1 or 2, where the input rotor magnetic material consists of one or more permanent magnets.
4. A system according to claims 1 or 2, where the input rotor magnetic material consists of one or more electromagnets.
5. A system according to claims 1 or 2 and claim 4 where the current supplied to the electromagnets is controllable.
6. A system according to any of the preceding claims, where switches are provided between the windings of the output rotor situated adjacent to the input rotor and the windings of the output rotor situated adjacent to the stator so that two rotating magnetic fields are created rotating in opposite directions.
7. A system according to any of the preceding claims, where switches are provided between the windings on the stator situated adjacent to the input rotor and the windings on the stator adjacent to the output rotor so that two rotating magnetic fields are created rotating in opposite directions.
8. A system according to claims 6 and 7, wherein rotation of the input rotor causes the output rotor to rotate in the opposite direction to the input rotor.
9. A system according to any of the preceding claims, where the angular position of the stator adjacent to the input rotor is adjustable relative to the angular position of the stator adjacent to the output rotor.
10. A system according to claim 9, where the two components of the stator are linked by resilient biasing means so the angular adjustment is provided automatically.
11. A system according to any of the preceding claims, where the angular position of the output rotor adjacent to the input rotor is adjustable relative to the angular position of the output rotor adjacent to the stator.
12. A system according to claim 11, where the two components of the output rotor are linked by resilient biasing means so the angular adjustment is provided automatically.
13. A system according to any of the preceding claims, where some or all of the current generated in the stator is extracted to provide a braking force on the output rotor.

14. A system according to any of the preceding claims, where some or all of the current generated in the stator is extracted to regenerate an energy storage device.
15. A system according to any of the preceding claims, where electrical power is imported into the stator to provide additional power.
16. A system according to claim 15, where the input rotor is disconnected and allowed to rotate freely so that the imported electrical power is providing all the motive force to the output rotor.
17. A system according to any of the preceding claims, where a lock-up device is provided for synchronising output rotor speed with input rotor speed at a given gearing ratio.
18. A vehicle or cycle incorporating one or more systems according to any of the preceding claims.
19. A vehicle or cycle according to claim 18, where the input rotor(s) is(are) connected to the vehicle motor or human motive power and the output rotor(s) to one or more driving wheels of the vehicle.
20. A vehicle or cycle according to claim 19, where drive from the vehicle motor to the input rotor is disconnectable under certain conditions to enable the system to be utilised as an electric motor.
21. A vehicle or cycle according to any of the claims 18 to 20, where electrical power is extractable from the stator to act as a vehicle brake.
22. A vehicle or cycle according to any of the claims 18 to 21, where electrical power is extractable from the stator to regenerate an energy storage device.
23. A vehicle or cycle according to any of the claims 18 to 22, where electrical power is imported to the stator to provide additional power.
24. A system substantially as described herein, with reference to the embodiments of Figures 1 and 2.





Application No: GB 9522658.5  
Claims searched: 1-24

Examiner: John Cockitt  
Date of search: 17 January 1997

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H2A [AKQQ, AKQ1, AKS6, AKGG]

Int Cl (Ed.6): H02K [16/02, 51/00]

Other:

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
X	GB2278242A FLACK - see whole document	1,4-10,13-23 at least
X	GB2078016A P.A. MANAGEMENT - see whole document	1,3 at least
X	US4532447A CIBIÉ - see whole document	1,4-7 at least

X Document indicating lack of novelty or inventive step  
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P Document published on or after the declared priority date but before the filing date of this invention.

E Patent document published on or after, but with priority date earlier than, the filing date of this application.